start here quick sheet

World Bank EHS Guidelines (for Small Producing Mining Companies)
start here quick sheet

World Bank Environmental, Health, and Safety (EHS) Guidelines (for Small Producing Mining Companies)

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This document has been tailored to present solutions to the issues which small producing mining companies should manage from exploration through construction towards production. It mainly provides guidance on impact management and mine design. This document has pulled select key advice out of the comprehensive 100-page “Environmental, Health and Safety General Guidelines” document, as well as from the 30-page “Environmental, Health and Safety Guidelines for Mining”. This is not an official World Bank document, nor has it been endorsed by the World Bank, and the entire contents of this Quick Sheet are credited to the World Bank. If you begin to do work in this area, we suggest referring back to the original document, which can be found here:

http://www1.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/sustainability+framework/environmental,+health,+and+safety+guidelines/

Please note: The World Bank is currently engaged in a three-year process to review and update its EHS Guidelines (scheduled to be finalized in 2016). Please make sure to periodically check the IFC website for the most up-to-date information:

http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/sustainability+framework/environmental,+health,+and+safety+guidelines/ehs+guidelines+technical+revision/
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1. Introducing the World Bank EHS Guidelines

The World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) are technical reference documents with examples of good international industry practice. The International Finance Corporation uses the EHS Guidelines as a technical source of information during project appraisal. The EHS Guidelines contain the performance levels and measures that are normally acceptable to the IFC, and that are generally considered to be achievable in new facilities at reasonable costs by existing technology. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The EHS Guidelines for Mining are applicable to underground and open-pit mining, alluvial mining, solution mining and marine dredging. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent.
2.1 AIR EMISSIONS AND AMBIENT AIR QUALITY

The generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency
- Process modification
- Selection of fuels or other materials, the processing of which may result in less polluting emissions
- Application of emissions control techniques

The principal sources of emissions include fugitive dust from blasting, exposed surfaces such as tailings facilities, stockpiles, waste dumps, haul roads and infrastructure, and to a lesser extent, gases from combustion of fuels in stationary and mobile equipment.

### Dust

The most common pollutant involved in fugitive emissions is dust or particulate matter (PM). This is released during certain operations, such as transport and open storage of solid materials, and from exposed soil surfaces, including unpaved roads.

#### Recommended dust management strategies include:

- Dust suppression techniques (e.g. wetting down, use of all-weather surfaces, use of agglomeration additives) for roads and work areas, optimization of traffic patterns and reduction of travel speeds
- Exposed soils and other erodible materials should be revegetated or covered promptly
- New areas should be cleared and opened-up only when absolutely necessary
- Surfaces should be re-vegetated or otherwise rendered non-dust forming when inactive
- Storage for dusty materials should be enclosed or operated with efficient dust suppressing measures
- Loading, transfer and discharge of materials should take place with a minimum height of fall, and be shielded against the wind
- Conveyor systems for dusty materials should be covered and equipped with measures for cleaning return belts
### Ambient Air Quality

Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines.
  - Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, and ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological and epidemiological evidence (such as those published by the World Health Organization).
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. **As a general rule, this Guideline suggests 25 percent of the applicable air quality standards** to allow additional, future sustainable development in the same air shed.

At facility level, impacts should be estimated through qualitative or quantitative assessments by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Local atmospheric, climatic and air quality data should be applied when modeling dispersion, protection against atmospheric downwash, wakes or eddy effects of the source, nearby structures and terrain features.

### WHO Ambient Air Quality Guidelines

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Period</th>
<th>Guideline value in µg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur dioxide (SO₂)</td>
<td>24-hour</td>
<td>125 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 (Interim target-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 (guideline)</td>
</tr>
<tr>
<td></td>
<td>10 minute</td>
<td>500 (guideline)</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>1-year</td>
<td>40 (guideline)</td>
</tr>
<tr>
<td></td>
<td>1-hour</td>
<td>200 (guideline)</td>
</tr>
<tr>
<td>Particulate Matter PM₁₀</td>
<td>1-year</td>
<td>70 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 (Interim target-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30 (Interim target-3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 (guideline)</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>150 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 (Interim target-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75 (Interim target-3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 (guideline)</td>
</tr>
<tr>
<td>Particulate Matter PM₂.₅</td>
<td>1-year</td>
<td>35 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 (Interim target-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 (Interim target-3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 (guideline)</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>75 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 (Interim target-2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37.5 (Interim target-3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 (guideline)</td>
</tr>
<tr>
<td>Ozone</td>
<td>8-hour daily maximum</td>
<td>160 (Interim target-1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 (guideline)</td>
</tr>
</tbody>
</table>

*Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.
Smelting and Roasting

General recommendations related to smelting and refining may be found in the EHS Guidelines for Base Metal Smelting and Refining. However, there are a few issues which are specific to the roasting and smelting of precious metals. Typically gold and silver is produced in small melting / fluxing furnaces which produce limited emissions but have the potential for mercury emissions from certain ores. Testing should be undertaken prior to melting to determine whether a mercury retort is required for mercury collection.

Operations that employ roasting of concentrates are often associated with elevated levels of mercury, arsenic and other metals as well as SO2 emissions. Recommended management strategies include:

- Operations at controlled temperature (higher temperature roasters generally cause more problems of contaminant control)
- Inclusion of an appropriate gas scrubbing system

Smelting of Platinum Group Metals (PGM) is similar to nickel and aluminum smelting. Care should be taken to avoid formation of nickel carbonyl and chromium VI during the smelting process. Where methane drainage (venting) is practiced, consideration should be given to beneficial utilization of the gas.

Greenhouse Gases

Recommendations for reduction and control of greenhouse gases include:

- Enhancement of energy efficiency
- Protection and enhancement of sinks and reservoirs
- Promotion of sustainable forms of agriculture and forestry
- Promotion, development and increased use of renewable forms of energy

Air Emissions Estimation and Dispersion Modeling Methods

The following is a partial list of documents to aid in the estimation of air emissions from various processes and air dispersion models:

- OECD Chemical Safety and Biosafety databases http://www.oecd.org/env/ehs/directoriesanddatabasesforchemicalsandbiosafety.htm
## Illustrative Point Source Air Emissions Prevention and Control Technologies

<table>
<thead>
<tr>
<th>Principal Sources and Issues</th>
<th>General Prevention / Process Modification Approach</th>
<th>Control Options</th>
<th>Reduction Efficiency (%)</th>
<th>Gas Condition</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Particulate Matter (PM)</strong></td>
<td><strong>Main sources are the combustion of fossil fuels and numerous manufacturing processes that collect PM through air extraction and ventilation systems. Volcanoes, ocean spray, forest fires and blowing dust (most prevalent in dry and semi-arid climates) contribute to background levels.</strong></td>
<td><strong>Fabric Filters</strong></td>
<td>99 - 99.7%</td>
<td>Dry gas, temp &lt;400°F</td>
<td>Applicability depends on flue gas properties including temperature, chemical properties, abrasion and load. Typical air to cloth ratio range of 2.0 to 3.5 cfm/ft^2^ Achievable outlet concentrations of 23 mg/Nm^3^</td>
</tr>
<tr>
<td></td>
<td><strong>Fuel switching (e.g. selection of lower sulfur fuels) or reducing the amount of fine particulates added to a process.</strong></td>
<td><strong>Electrostatic Precipitator (ESP)</strong></td>
<td>97 – 99%</td>
<td>Varies depending of particle type</td>
<td>Precondition gas to remove large particles. Efficiency dependent on resistivity of particle. Achievable outlet concentration of 23 mg/Nm^3^</td>
</tr>
<tr>
<td></td>
<td><strong>Cyclone</strong></td>
<td>74 – 95%</td>
<td>None</td>
<td>Most efficient for large particles. Achievable outlet concentrations of 30 - 40 mg/Nm^3^</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Wet Scrubber</strong></td>
<td>93 – 95%</td>
<td>None</td>
<td>Wet sludge may be a disposal problem depending on local infrastructure. Achievable outlet concentrations of 30 - 40 mg/Nm^3^</td>
<td></td>
</tr>
<tr>
<td><strong>Sulfur Dioxide (SO₂)</strong></td>
<td><strong>Mainly produced by the combustion of fuels such as oil and coal and as a by-product from some chemical production or wastewater treatment processes.</strong></td>
<td><strong>Fuel Switching</strong></td>
<td>&gt;90%</td>
<td></td>
<td>Alternate fuels may include low sulfur coal, light diesel or natural gas with consequent reduction in particulate emissions related to sulfur in the fuel. Fuel cleaning or beneficiation of fuels prior to combustion is another viable option but may have economic consequences.</td>
</tr>
<tr>
<td></td>
<td><strong>Control system selection is heavily dependent on the inlet concentration. For SO₂ concentrations in excess of 10%, the stream is passed through an acid plant not only to lower the SO₂ emissions but also to generate high grade sulfur for sale. Levels below 10% are not rich enough for this process and should therefore utilize absorption or ‘scrubbing,’ where SO₂ molecules are captured into a liquid phase or adsorption, where SO₂ molecules are captured on the surface of a solid adsorbent.</strong></td>
<td><strong>Sorbent Injection</strong></td>
<td>30% - 70%</td>
<td>Calcium or lime is injected into the flue gas and the SO₂ is adsorbed onto the sorbent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Dry Flue Gas Desulfurization</strong></td>
<td>70%-90%</td>
<td></td>
<td>Can be regenerable or throwaway.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Wet Flue Gas Desulfurization</strong></td>
<td>&gt;90%</td>
<td></td>
<td>Produces gypsum as a by-product</td>
</tr>
</tbody>
</table>
IlluSTraTIvE PoInT SourCE aIr EMISSIonS PrEvEnTIon and ConTrol TECHnoloGIES

<table>
<thead>
<tr>
<th>Oxides of Nitrogen (NOx)</th>
<th>Percent Reduction by Fuel Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated with combustion of fuel. May occur in several forms of nitrogen oxide; namely nitric oxide (NO) nitrogen dioxide (NO₂) and nitrous oxide (N₂O), which is also a greenhouse gas. The term NOx serves as a composite between NO and NO₂ and emissions are usually reported as NOx. Here the NO is multiplied by the ratio of molecular weights of NO₂ to NO and added to the NO₂ emissions. Means of reducing NOx emissions are based on the modification of operating conditions such as minimizing the resident time at peak temperatures, reducing the peak temperatures by increasing heat transfer rates or minimizing the availability of oxygen.</td>
<td>Combustion modification (Illustrative of boilers)</td>
<td>Coal</td>
</tr>
<tr>
<td>Low-excess-air firing</td>
<td>10–30</td>
<td>10–30</td>
</tr>
<tr>
<td>Staged Combustion</td>
<td>20–50</td>
<td>20–50</td>
</tr>
<tr>
<td>Flue Gas Recirculation</td>
<td>N/A</td>
<td>20–50</td>
</tr>
<tr>
<td>Water/Steam Injection</td>
<td>N/A</td>
<td>10–50</td>
</tr>
<tr>
<td>Low-NOx Burners</td>
<td>30–40</td>
<td>30–40</td>
</tr>
<tr>
<td>Flue Gas Treatment</td>
<td>Coal</td>
<td>Oil</td>
</tr>
<tr>
<td>Selective Catalytic Reduction (SCR)</td>
<td>60–90</td>
<td>60–90</td>
</tr>
<tr>
<td>Selective Non-Catalytic Reduction (SNCR)</td>
<td>N/A</td>
<td>30–70</td>
</tr>
</tbody>
</table>

These modifications are capable of reducing NOx emissions by 50 to 95%. The method of combustion control used depends on the type of boiler and the method of firing fuel. Flue gas treatment is more effective in reducing NOx emissions than are combustion controls. Techniques can be classified as SCR, SNCR, and adsorption. SCR involves the injection of ammonia as a reducing agent to convert NOx to nitrogen in the presence of a catalyst in a converter upstream of the air heater. Generally, some ammonia slips through and is part of the emissions. SNCR also involves the injection of ammonia or urea based products without the presence of a catalyst.
Monitoring

The air quality monitoring program should consider the following elements:

- **Monitoring parameters**: The monitoring parameters selected should reflect the pollutants of concern associated with project processes.
- **Baseline calculations**: Before a project is developed, baseline air quality monitoring at and in the vicinity of the site should be undertaken to assess background levels of key pollutants, in order to differentiate between existing ambient conditions and project-related impacts.
- **Monitoring type and frequency**: Data on emissions and ambient air quality generated through the monitoring program should be representative of the emissions discharged by the project over time. Emissions monitoring frequency and duration may also range from continuous for some combustion process operating parameters or inputs (e.g. the quality of fuel) to less frequent, monthly, quarterly or yearly stack tests.
- **Monitoring locations**: Ambient air quality monitoring may consist of off-site or fence line monitoring either by the project sponsor, the competent government agency or by collaboration between both. The location of ambient air quality monitoring stations should be established based on the results of scientific methods and mathematical models to estimate potential impact to the receiving airshed from an emissions source taking into consideration such aspects as the location of potentially affected communities and prevailing wind directions.

- **Sampling and analysis methods**: Monitoring programs should apply national or international methods for sample collection and analysis, such as those published by the International Organization for Standardization (ISO). Sampling should be conducted by, or under, the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance / Quality Control (QA/QC) plans should be applied and documented to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). Monitoring reports should include QA/QC documentation.

2.2 LAND USE AND BIODIVERSITY

Habitat alteration is one of the most significant potential threats to biodiversity associated with mining. Habitat alteration may occur during any stage of the mine cycle. Exploration activities often require the development of access routes, transportation corridors and temporary camps to house workers which may all result in varying degrees of land-clearing and population in-migration. The protection and conservation of biodiversity is fundamental to sustainable development.

Recommended strategies include consideration of the following:

- Whether any critical natural habitats will be adversely impacted or critically endangered or endangered species reduced
  - Critical natural habitat: As defined in IFC’s Performance Standard (PS) 6 – Biodiversity Conservation and Sustainable Natural Resource Management. Readers should consult the definition and requirements applicable to Critical Habitat in the PS.
- Whether the project is likely to impact any protected areas
- The potential for biodiversity offset projects (e.g. proactive management of alternative high biodiversity areas in cases where losses have occurred on the main site due to the mining development) or other mitigative measures
- Whether the project or its associated infrastructure will encourage in-migration, which could adversely impact biodiversity and local communities;
- Consideration of partnerships with internationally accredited scientific organizations to, for example, undertake biodiversity assessments, conduct ongoing monitoring and manage biodiversity programs
- Consultation with key stakeholders (e.g. government, civil society and potentially affected communities) to understand any conflicting land use demands and the communities dependency on natural resources and / or conservation requirements that may exist in the area

Terrestrial Habitats

Recommended management strategies include:

- Siting access routes and facilities in locations that avoid impacts to critical terrestrial habitat, and planning exploration and construction activities to avoid sensitive times of the year
- Minimizing disturbance to vegetation and soils
- Implementing mitigation measures appropriate for the type of habitat and potential impacts including, for example, post-operation restoration (which may include baseline inventories, evaluations and eventual rescue of species), offset of losses or compensation of direct users
- Avoiding or minimizing the creation of barriers to wildlife movement or threats to migratory species (such as birds), and providing alternative migration routes when the creation of barriers cannot be avoided
- Planning and avoiding sensitive areas and implementing buffer zones
- Implementing soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation); key factors such as placement,
location, design, duration, coverage, reuse and single handling should be considered

- Where topsoil is pre-stripped, it should be stored for future site rehabilitation activities. Topsoil management should include maintenance of soil integrity in readiness for future use. Storage areas should be temporarily protected or vegetated to prevent erosion

Aquatic Habitats

Aquatic habitats may be altered through changes in surface water and groundwater regimes, and resulting increased pressures on fish and wildlife communities. Earth-moving operations may mobilize sediment which can enter watercourses and disrupt water quality and quantity.

Recommended management strategies include the following:

- Minimizing the creation and extent of new access corridors
- Decommissioning and re-vegetating exploration access routes and installing barricades to limit access
- Maintaining, to the extent possible, natural drainage paths and restoring them if they are disrupted
- Maintaining water body catchment areas equal or comparable to pre-development conditions

- Protecting stream channel stability by limiting in-stream and bank disturbance and employing appropriate setback from riparian zones
- Attenuating surface runoff from high precipitation events using on-site storage and water management infrastructure (e.g. storage ponds, sumps, low gradient ditches, clean water diversions)
- Designing temporary and permanent bridges and culverts to manage peak flows depending on the associated potential risk
- Constructing, maintaining and reclaiming watercourse crossings that are stable, safe for the intended use, and that minimize erosion, mass wasting and degradation of the channel or lakebed

Marine Habitats

Key impacts of concern to the marine environment may include habitat disturbance and destruction, suspension of sediment in the water column, change in water temperature and changed water quality. Project sponsors should engage the services of appropriate specialists to carry out marine impact assessments which also include socio-economic impacts (e.g. impacts on fishing grounds).
2.3 ENERGY USE

Energy Conservation

Energy management programs should include the following elements:

- Identification, and regular measurement and reporting of principal energy flows within a facility at unit process level
- Preparation of mass and energy balance
- Definition and regular review of energy performance targets, which are adjusted to account for changes in major influencing factors on energy use
- Regular comparison and monitoring of energy flows with performance targets to identify where action should be taken to reduce energy use
- Regular review of targets, which may include comparison with benchmark data, to confirm that targets are set at appropriate levels

Recommended energy conservation measures include the following:

- Use of non-invasive technologies such as remote sensing and ground-based technologies to minimize exploratory digging and drilling
- Correctly sizing motors and pumps used in the excavation, ore moving, ore crushing and ore handling process, as well as using adjustable speed drives (ASDs) in applications with highly varying load requirements

Energy Efficiency

For any energy-using system, a systematic analysis of energy efficiency improvements and cost reduction opportunities should include a hierarchical examination of opportunities to:

- Demand/Load Side Management by reducing loads on the energy system
- Supply Side Management by:
  - Reducing losses in energy distribution
  - Improving energy conversion efficiency
  - Exploiting energy purchasing opportunities
  - Using lower-carbon fuels
Process Heating

Process heating is vital to many manufacturing processes, including heating for fluids, calcining, drying, heat treating, metal heating, melting, melting agglomeration, curing and forming. In process heating systems, a system heat and mass balance will show how much of the system’s energy input provides true process heating, and quantify fuel used to satisfy energy losses caused by excessive parasitic loads, distribution or conversion losses. Examination of savings opportunities should be directed by the results of the heat and mass balance, though the following techniques are often valuable and cost-effective.

Heating Load Reduction:

- Ensure adequate insulation to reduce heat losses through furnace/oven etc. structure
- Recover heat from hot process or exhaust streams to reduce system loads
- In intermittently-heated systems, consider use of low thermal mass insulation to reduce energy required to heat the system structure to operating temperature
- Control process temperature and other parameters accurately to avoid, for example, overheating or overdrying
- Examine opportunities to use low weight and/or low thermal mass product carriers, such as heated shapers, kiln cars etc.
- Review opportunities to schedule work flow to limit the need for process reheating between stages
- Operate furnaces/ovens at slight positive pressure, and maintain air seals to reduce air in-leakage into the heated system, thereby reducing the energy required to heat unnecessary air to system operating temperature
- Reduce radiant heat losses by sealing structural openings and keep viewing ports closed when not in use
- Where possible, use the system for long runs close to or at operating capacity
- Consider use of high emissivity coatings of high temperature insulation, and consequent reduction in process temperature
- Near net weight and shape heat designs
- Robust Quality assurance on input material
- Robust Scheduled maintenance programs

Heat Distribution Systems:

Heat distribution in process heating applications typically takes place through steam, hot water or thermal fluid systems. Losses can be reduced through the following actions:

- Promptly repair distribution system leaks
- Avoid steam leaks despite a perceived need to get steam through the turbine. Electricity purchase is usually cheaper overall, especially when the cost to treat turbine-quality boiler feed water is included. If the heat-power ratio of the distribution process is less than that of power systems, opportunities should be considered to increase the ratio; for example, by using low-pressure steam to drive absorption cooling systems rather than using electrically-driven vapor- compression systems
- Regularly verify correct operation of steam traps in steam systems, and ensure that traps are not bypassed. Since steam traps typically last approximately 5 years, 20% should be replaced or repaired annually
• Insulate distribution system vessels, such as hot wells and de-aerators, in steam systems and thermal fluid or hot water storage tanks
• Insulate all steam, condensate, hot water and thermal fluid distribution pipework, down to and including 1” (25 mm) diameter pipe, in addition to insulating all hot valves and flanges
• In steam systems, return condensate to the boiler house for re-use, since condensate is expensive boiler-quality water and valuable beyond its heat content alone
• Use flash steam recovery systems to reduce losses due to evaporation of high-pressure condensate
• Consider steam expansion through a back-pressure turbine rather than reducing valve stations
• Eliminate distribution system losses by adopting point-of-use heating systems

Energy Conversion System Efficiency Improvements:

The following efficiency opportunities should be examined for process furnaces or ovens and utility systems, such as boilers and fluid heaters:

• Regularly monitor CO, oxygen or CO2 content of flue gases to verify that combustion systems are using the minimum practical excess air volumes
• Consider combustion automation using oxygen-trim controls
• Minimize the number of boilers or heaters used to meet loads. It is typically more efficient to run one boiler at 90% of capacity than two at 45%.
• Minimize the number of boilers kept at hot-standby
• Use flue dampers to eliminate ventilation losses from hot boilers held at standby

• Maintain clean heat transfer surfaces; in steam boilers, flue gases should be no more than 20 K above steam temperature
• In steam boiler systems, use economizers to recover heat from flue gases to pre-heat boiler feed water or combustion air
• Consider reverse osmosis or electrodialysis feed water treatment to minimize the requirement for boiler blowdown
• Adopt automatic (continuous) boiler blowdown
• Recover heat from blowdown systems through flash steam recovery or feed-water preheat
• Do not supply excessive quantities of steam to the de-aerator
• With fired heaters, consider opportunities to recover heat to combustion air through the use of recuperative or regenerative burner systems
• For systems operating for extended periods (> 6000 hours/year), cogeneration of electrical power, heat and/or cooling can be cost effective
• Oxy Fuel burners
• Oxygen enrichment/injection
• Use of turbolators in boilers
• Sizing design and use of multiple boilers for different load configurations
• Fuel quality control/fuel blending
2.4 WATER

Management of water use and quality, in and around mine sites, can be a significant issue. Potential contamination of water sources may occur early in the mine cycle during the exploration stage and many factors including indirect impacts (e.g. population immigration) can result in negative impacts to water quality. Reduction of surface and groundwater availability is also a concern at the local level and for communities in the vicinity of mining sites (particularly in arid regions or in regions of high agricultural potential). Mining activities should therefore include adequate monitoring and management of water use, in addition to treatment of effluent streams including storm water run-off from the mine property.

Water Use

Mines can use large quantities of water, mostly in processing plants and related activities, but also in dust suppression among other uses. Water is lost through evaporation in the final product but the highest losses are usually into the tailings stream. All mines should focus on appropriate management of their water balance. Mines with issues of excess water supply, such as in moist tropical environments or areas with snow and ice melt, can experience peak flows which require careful management. Recommended practices for water management include:

- Establishing a water balance (including probable climatic events) for the mine and related process plant circuit and use this to inform infrastructure design

- Developing a Sustainable Water Supply Management Plan to minimize impact to natural systems by managing water use, avoiding depletion of aquifers and minimizing impacts to water users;

- Minimizing the amount of make-up water

- Consider reuse, recycling and treatment of process water where feasible (e.g. return of supernatant from tailings pond to process plant)

- Consultation with key stakeholders (e.g. government, civil society and potentially affected communities) to understand any conflicting water use demands and the communities’ dependency on water resources and/or conservation requirements that may exist in the area

Water Quality and Availability

Groundwater and surface water represent essential sources of drinking and irrigation water in developing countries, particularly in rural areas where piped water supply may be limited or unavailable and where available resources are collected by the consumer with little or no treatment. Project activities involving wastewater discharges, water extraction, diversion or impoundment should prevent adverse impacts to the quality and availability of groundwater and surface water resources.

Water Quality:

Drinking water sources, whether public or private, should at all times be protected so that they meet or exceed applicable national acceptability standards or in their absence the current edition of WHO Guidelines for Drinking-Water Quality.
Water Availability:

The potential effect of groundwater or surface water abstraction for project activities should be properly assessed through a combination of field testing and modeling techniques, accounting for seasonal variability and projected changes in demand in the project area. Project activities should not compromise the availability of water for personal hygiene needs and should take account of potential future increases in demand. The overall target should be the availability of 100 liters per person per day although lower levels may be used to meet basic health requirements. Water volume requirements for well-being-related demands such as water use in health care facilities may need to be higher.

- World Health Organization (WHO) defines 100 liters/capita/day as the amount required to meet all consumption and hygiene needs.

Wastewater and Ambient Water Quality

This guideline applies to projects that have either direct or indirect discharge of process wastewater, wastewater from utility operations or storm water to the environment. These guidelines are also applicable to industrial discharges to sanitary sewers that discharge to the environment without any treatment. Process wastewater may include contaminated wastewater from utility operations, storm water and sanitary sewage. It provides information on common techniques for wastewater management, water conservation and reuse that can be applied to a wide range of industry sectors.

Storm Water

Key issues associated with management of storm water include separation of clean and dirty water, minimizing run-off, avoiding erosion of exposed ground surfaces, avoiding sedimentation of drainage systems and minimizing exposure of polluted areas to storm water.

From exploration onwards, management strategies include:

- Reducing exposure of sediment-generating materials to wind or water (e.g. proper placement of soil and rock piles)
- Diverting run-off from undisturbed areas around disturbed areas including areas that have been graded, seeded or planted. Such drainage should be treated for sediment removal
- Reducing or preventing off-site sediment transport (e.g. use of settlement ponds, silt fences)
- Storm water drains, ditches and stream channels should be protected against erosion through a combination of adequate dimensions, slope limitation techniques and use of rip-rap and lining. Temporary drainage installations should be designed, constructed and maintained for recurrence periods of at least a 25-year/24-hour event, while permanent drainage installations should be designed for a 100-year/24-hour recurrence period. Design requirements for temporary drainage structures should additionally be defined on a risk basis considering the intended life of diversion structures, as well as the recurrence interval of any structures that drain into them.
Acid Rock Drainage and Metals Leaching

Acid Rock Drainage (ARD) refers to acid formation that occurs when Potentially Acid Generating (PAG) materials with acid generating sulfide minerals in excess of acid neutralizing minerals, principally carbonates, oxidize in an environment containing oxygen and water. Acidic conditions tend to dissolve and release metals from their matrices (a phenomenon known as Metals Leaching or “ML”) which then may be mobilized in surface and groundwater systems. ARD and ML should be prevented and controlled as described in the ‘Solid Waste ’ section of this document. Management of PAG, ARD and ML should extend for as long as there is a need to maintain effluent quality to the levels required to protect the local environment, including (where necessary) into the decommissioning, closure and post-closure phases of the mine. The ARD and ML issues apply to waste rock, tailing materials and any exposed rock surfaces such as road cuts and pit walls.

Groundwater Resource Protection

In addition to the prevention and control of effluents, wastes and potential releases of hazardous materials, additional recommendations for the management of potential sources of groundwater contamination, primarily associated with leaching and solution mining activities as well as tailings management include the following:

Operators should design and operate surface heap leach processes with:

- Infiltration of toxic leach solutions should be prevented through the provision of appropriate liners and sub-drainage systems to collect or...
Water Monitoring and Management

The essential elements of a water management program involve:

- Identification, regular measurement and recording of principal flows within a facility
- Definition and regular review of performance targets, which are adjusted to account for changes in major factors affecting water use (e.g. industrial production rate)
- Regular comparison of water flows with performance targets to identify where action should be taken to reduce water use
- Water measurement (metering) should emphasize areas of greatest water use

Septic Systems

Septic systems are commonly used for treatment and disposal of domestic sanitary sewage in areas with no sewerage collection networks. Septic systems should only be used for treatment of sanitary sewage, and are unsuitable for industrial wastewater treatment. When septic systems are the selected form of wastewater disposal and treatment, they should be:

- Properly designed and installed in accordance with local regulations and guidance to prevent any hazard to public health or contamination of land, surface or groundwater
- Well maintained to allow effective operation
- Installed in areas with sufficient soil percolation for the design wastewater loading rate
- Installed in areas of stable soils that are nearly level, well drained and permeable, with enough separation between the drain field and the groundwater table or other receiving waters

A wastewater and water quality monitoring program with adequate resources and management oversight should be developed and implemented to meet the objective(s) of the monitoring program. The wastewater and water quality monitoring program should consider the following elements:

- Monitoring parameters: The parameters selected for monitoring should be indicative of the pollutants of concern from the process, and should include parameters that are regulated under compliance requirements.
- Monitoring type and frequency: Wastewater monitoring should take into consideration the discharge characteristics from the process over time. Monitoring of discharges from processes with batch manufacturing or seasonal process variations should take into consideration of time-dependent variations in discharges and, therefore, is more

<table>
<thead>
<tr>
<th>INDICATIVE VALUES FOR TREATED SANITARY SEWAGE DISCHARGES</th>
<th>Pollutants</th>
<th>Units</th>
<th>Guideline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH</td>
<td></td>
<td>6 – 9</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/l</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>mg/l</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>mg/l</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Oil and grease</td>
<td>mg/l</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>mg/l</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td>MPN²/100 ml</td>
<td>400¹</td>
<td></td>
</tr>
</tbody>
</table>

¹ Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.  
² MPN = Most Probable Number
complex than monitoring of continuous discharges. Effluents from highly variable processes may need to be sampled more frequently or through composite methods. Grab samples or, if automated equipment permits, composite samples may offer more insight on average concentrations of pollutants over a 24-hour period. Composite samplers may not be appropriate where analyses of concern are short-lived (e.g., quickly degraded or volatile).

- **Monitoring locations**: The monitoring location should be selected with the objective of providing representative monitoring data. Effluent sampling stations may be located at the final discharge, as well as at strategic upstream points prior to merging of different discharges. Process discharges should not be diluted prior or after treatment with the objective of meeting the discharge or ambient water quality standards.

- **Data quality**: Monitoring programs should apply internationally approved methods for sample collection, preservation and analysis. Sampling should be conducted by or under the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and Analysis Quality Assurance/Quality Control (QA/QC) plans should be prepared and implemented. QA/QC documentation should be included in monitoring reports.

### Water Conservation

General recommendations include:

- Storm/Rainwater harvesting and use
- Zero discharge design/Use of treated waste water to be included in project design processes
- Use of localized recirculation systems in plant/facility/shops (as opposed to centralized recirculation system), with provision only for makeup water
- Use of dry process technologies e.g. dry quenching
- Process water system pressure management
- Project design to have measures for adequate water collection, spill control and leakage control system
<table>
<thead>
<tr>
<th>Pollutant/Parameter</th>
<th>Control Options / Principle</th>
<th>Common End of Pipe Control Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Chemical, Equalization</td>
<td>Acid/Base addition, Flow equalization</td>
</tr>
<tr>
<td>Oil and Grease / TPH</td>
<td>Phase separation</td>
<td>Dissolved Air Floatation, oil water separator, grease trap</td>
</tr>
<tr>
<td>TSS - Settleable</td>
<td>Settling, Size Exclusion</td>
<td>Sedimentation basin, clarifier, centrifuge, screens</td>
</tr>
<tr>
<td>TSS - Non-Settleable</td>
<td>Floatation, Filtration - traditional and tangential</td>
<td>Dissolved air floatation, Multimedia filter, sand filter, fabric filter, ultrafiltration, microfiltration</td>
</tr>
<tr>
<td>Hi - BOD (&gt; 2 Kg/m³)</td>
<td>Biological - Anaerobic</td>
<td>Suspended growth, attached growth, hybrid</td>
</tr>
<tr>
<td>Lo - BOD (&lt; 2 Kg/m³)</td>
<td>Biological - Aerobic, Facultative</td>
<td>Suspended growth, attached growth, hybrid</td>
</tr>
<tr>
<td>COD - Non-Biodegradable</td>
<td>Oxidation, Adsorption, Size Exclusion</td>
<td>Chemical oxidation, Thermal oxidation, Activated Carbon, Membranes</td>
</tr>
<tr>
<td>Metals - Particulate and Soluble</td>
<td>Coagulation, flocculation, precipitation, size exclusion</td>
<td>Flash mix with settling, filtration - traditional and tangential</td>
</tr>
<tr>
<td>Inorganics / Non-metals</td>
<td>Coagulation, flocculation, precipitation, size exclusion, Oxidation, Adsorption</td>
<td>Flash mix with settling, filtration - traditional and tangential, Chemical oxidation, Thermal oxidation, Activated Carbon, Reverse Osmosis, Evaporation</td>
</tr>
<tr>
<td>Organics - VOCs and SVOCs</td>
<td>Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation</td>
<td>Biological : Suspended growth, attached growth, hybrid; Chemical oxidation, Thermal oxidation, Activated Carbon</td>
</tr>
<tr>
<td>Emissions – Odors and VOCs</td>
<td>Capture – Active or Passive; Biological; Adsorption, Oxidation</td>
<td>Biological : Attached growth; Chemical oxidation, Thermal oxidation, Activated Carbon</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Biological Nutrient Removal, Chemical, Physical, Adsorption</td>
<td>Aerobic/Anoxic biological treatment, chemical hydrolysis and air stripping, chlorination, ion exchange</td>
</tr>
<tr>
<td>Color</td>
<td>Biological - Aerobic, Anaerobic, Facultative; Adsorption, Oxidation</td>
<td>Biological Aerobic, Chemical oxidation, Activated Carbon</td>
</tr>
<tr>
<td>Temperature</td>
<td>Evaporative Cooling</td>
<td>Surface Aerator, Flow Equalization</td>
</tr>
<tr>
<td>TDS</td>
<td>Concentration, Size Exclusion</td>
<td>Evaporation, crystallization, Reverse Osmosis</td>
</tr>
<tr>
<td>Active Ingredients/Emerging Contaminants</td>
<td>Adsorption, Oxidation, Size Exclusion, Concentration</td>
<td>Chemical oxidation, Thermal oxidation, Activated Carbon, Ion Exchange, Reverse Osmosis, Evaporation, Crystallization</td>
</tr>
<tr>
<td>Radionuclides</td>
<td>Adsorption, Size Exclusion, Concentration</td>
<td>Ion Exchange, Reverse Osmosis, Evaporation, Crystallization</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Disinfection, Sterilization</td>
<td>Chlorine, Ozone, Peroxide, UV, Thermal</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Adsorption, Oxidation, Size Exclusion, Concentration</td>
<td>Chemical oxidation, Thermal oxidation, Activated Carbon, Evaporation, crystallization, Reverse Osmosis</td>
</tr>
</tbody>
</table>
3. Community Health and Safety

Community health and safety issues that may be associated with mining activities include transport safety along access corridors, transport and handling of dangerous goods, impacts to water quality and quantity, inadvertent development of new vector breeding sites and potential for transmission of communicable diseases (e.g., respiratory and sexually transmitted infections resulting from the influx of project labor). In addition, there can be significant household and community level effects on the social determinants of health (e.g., drug, alcohol, gender violence and other psychosocial effects), associated with the rapid influx of labor during construction and operational phases. The rapid influx of labor and their associated extended family members may also place a significant burden on existing community health facilities and resources.

3.1 Emergency Preparedness and Response

An Emergency Response Plan should be prepared in accordance with the guidance of the UNEP APPEL for Mining: Awareness and Preparedness for Emergencies at the Local Level process (APEL for Mining, Awareness and Preparedness for Emergencies at Local Level, Technical Report No. 41, UNEP 2001). The report provides a framework for preparation of an Emergency Response Plan involving the mine, emergency response agencies, local authorities and communities.

3.2 Communicable Diseases

Worker living quarters that are designed and maintained to prevent over-crowding can reduce the transmission of communicable respiratory diseases that may transfer to local communities.
3.3 HAZARDOUS MATERIALS MANAGEMENT

These guidelines apply to projects that use, store or handle any quantity of hazardous materials (Hazmats), defined as materials that represent a risk to human health, property or the environment due to their physical or chemical characteristics.

The overall objective of hazardous materials management is to avoid or, when avoidance is not feasible, minimize uncontrolled releases of hazardous materials or accidents (including explosion and fire) during their production, handling, storage and use. This objective can be achieved by:

- Using engineering controls (containment, automatic alarms and shut-off systems) commensurate with the nature of hazard
- Implementing management controls (procedures, inspections, communications, training and drills) to address residual risks that have not been prevented or controlled through engineering measures

Hazard Assessment

The level of risk should be established through an ongoing assessment process based on:

- The types and amounts of hazardous materials present in the project. This information should be recorded and should include a summary table with the following information:
  - Name and description (e.g. composition of a mixture) of the Hazmat
  - Classification (e.g. code, class or division) of the Hazmat
  - Internationally accepted regulatory reporting threshold quantity or national equivalent of the Hazmat
  - Quantity of Hazmat used per month
  - Characteristic(s) that make(s) the Hazmat hazardous (e.g. flammability, toxicity)
- Analysis of potential spill and release scenarios using available industry statistics on spills and accidents where available
- Analysis of the potential for uncontrolled reactions such as fire and explosions
- Analysis of potential consequences based on the physical-geographical characteristics of the project site, including aspects such as its distance to settlements, water resources and other environmentally sensitive areas

Hazard assessment should be performed by specialized professionals using internationally-accepted methodologies such as Hazardous Operations Analysis (HAZOP), Failure Mode and Effects Analysis (FMEA) and Hazard Identification (HAZID)
Release Prevention and Control Planning

In order to minimize the risk associated with accidental spills from storage tanks and pipelines (e.g. tailings pipelines) the recommended mitigation measures include:

- Providing secondary containment to restrict movement into receiving water bodies (e.g. sumps, holding areas, impermeable liners), for example:
  - Constructing pipelines with double-walled or thick-walled sections at critical locations (e.g. large stream crossings)
  - Installing shutoff valves to minimize spill volumes and to isolate flow in critical areas

Where there is risk of a spill of uncontrolled hazardous materials, facilities should prepare a spill control, prevention and countermeasure plan as a specific component of their Emergency Preparedness and Response Plan. The plan should be tailored to the hazards associated with the project, and include:

- Training of operators on release prevention, including drills specific to hazardous materials as part of emergency preparedness response training
- Implementation of inspection programs to maintain the mechanical integrity and operability of pressure vessels, tanks, piping systems, relief and vent valve systems, containment infrastructure, emergency shutdown systems, controls and pumps and associated process equipment
- Preparation of written Standard Operating Procedures (SOPs) for filling USTs, ASTs or other containers or equipment, as well as for transfer operations by personnel trained in the safe transfer and filling of the hazardous material, and in spill prevention and response
- SOPs for the management of secondary containment structures, specifically the removal of any accumulated fluid, such as rainfall, to ensure that the intent of the system is not accidentally or willfully defeated
- Identification of locations of hazardous materials and associated activities on an emergency plan site map
- Documentation of availability of specific personal protective equipment and training needed to respond to an emergency
- Documentation of availability of spill response equipment sufficient to handle at least initial stages of a spill and a list of external resources for equipment and personnel, if necessary, to supplement internal resources
- Description of response activities in the event of a spill, release or other chemical emergency including:
  - Internal and external notification procedures
  - Specific responsibilities of individuals or groups
  - Decision process for assessing severity of the release and determining appropriate actions
  - Facility evacuation routes
  - Post-event activities such as clean-up and disposal, incident investigation, employee re-entry and restoration of spill response equipment

Cyanide

Cyanide use should be consistent with the principles and standards of practice of the International Cyanide Management Code, available at: http://www.cyanidecode.org/
Transport of Hazardous Materials


Management Actions

- **Management of Change:** These procedures should address:
  - The technical basis for changes in processes and operations
  - The impact of changes on health and safety
  - Modification to operating procedures
  - Authorization requirements
  - Employees affected
  - Training needs

- **Compliance Audit:** A compliance audit is a way to evaluate compliance with the prevention program requirements for each process. A compliance audit covering each element of the prevention measures (see below) should be conducted at least every three years and should include:
  - Preparation of a report of the findings
  - Determination and documentation of the appropriate response to each finding
  - Documentation that any deficiency has been corrected

- **Incident Investigation:** Incidents can provide valuable information about site hazards and the steps needed to prevent accidental releases. An incident investigation mechanism should include procedures for:
  - Initiation of the investigation promptly
  - Summarizing the investigation in a report
  - Addressing the report findings and recommendations
  - A review of the report with staff and contractors

- **Employee Participation:** A written plan of action should describe an active employee participation program for the prevention of accidents.

- **Contractors:** There should be a mechanism for contractor control which should include a requirement for them to develop hazard materials management procedures that meet the requirements of the hazardous materials management plan. Their procedures should be consistent with those of the contracting company and the contractor workforce should undergo the same training. Additionally, procedures should require that contractors are:
  - Provided with safety performance procedures and safety and hazard information
  - Observe safety practices
  - Act responsibly
  - Have access to appropriate training for their employees
  - Ensure that their employees know process hazards and applicable emergency actions
  - Prepare and submit training records for their employees to the contracting company
  - Inform their employees about the hazards presented by their work
  - Assess trends of repeated similar incidents
  - Develop and implement procedures to manage repeated similar incidents

- **Training:** Project employees should be provided training on Hazmat management. The training program should include:
  - A list of employees to be trained
Planning Coordination:

- Procedures should be prepared for:
  - Informing the public and emergency response agencies
  - Documenting first aid and emergency medical treatment
  - Taking emergency response actions
  - Reviewing and updating the emergency response plan to reflect changes, and ensuring that employees are informed of such changes

Emergency Preparation and Response:

- Specific training objectives
- Mechanisms to achieve the objectives (i.e., hands-on workshops, videos, etc.)
- The means to determine whether the training program is effective
- Training procedures for new hires and refresher courses for existing employees

Preventive Measures:

Recommended aspects of the inspection and maintenance program include:

- Developing inspection and maintenance procedures
- Establishing a quality assurance plan for equipment, maintenance materials and spare parts
- Conducting employee training on the inspection and maintenance procedures
- Conducting equipment, piping and instrumentation inspections and maintenance
- Identifying and correcting identified deficiencies
- Evaluating the inspection and maintenance results and, if necessary, updating the inspection and maintenance procedures
- Reporting the results to management

Emergency Preparedness and Response:

Procedures and practices should be developed allowing for quick and efficient responses to accidents that could result in human injury or damage to the environment. An Emergency Preparation and Response Plan, incorporated into and consistent with, the facility’s overall ES/OHS MS, should be prepared to cover the following:

- Planning Coordination: procedures should be prepared for:
  - Informing the public and emergency response agencies
  - Documenting first aid and emergency medical treatment
  - Taking emergency response actions
  - Reviewing and updating the emergency response plan to reflect changes, and ensuring that employees are informed of such changes
- Emergency Equipment: Procedures should be prepared for using, inspecting, testing and maintaining the emergency response equipment.
- Training: Employees and contractors should be trained on emergency response procedures.

All projects should have an Emergency Preparedness and Response Plan that is commensurate with the risks of the facility and that includes the following basic elements:

- Administration (policy, purpose, distribution, definitions, etc)
- Organization of emergency areas (command centers, medical stations, etc)
- Roles and responsibilities
- Communication systems
- Emergency response procedures
- Emergency resources
- Training and updating
- Checklists (role and action list and equipment checklist)
- Business Continuity and Contingency
Community Involvement and Awareness

When hazardous materials are in use above threshold quantities, the management plan should include a system for community awareness, notification and involvement that should be commensurate with the potential risks identified for the project during the hazard assessment studies. This should include mechanisms for sharing the results of hazard and risk assessment studies in a timely, understandable and culturally sensitive manner with potentially affected communities that provides a means for public feedback. Community involvement activities should include:

- Availability of general information to the potentially affected community on the nature and extent of project operations, and the prevention and control measures in place to ensure no effects to human health
- The potential for off-site effects to human health or the environment following an accident at planned or existing hazardous installations
- Specific and timely information on appropriate behavior and safety measures to be adopted in the event of an accident including practice drills in locations with higher risks
- Access to information necessary to understand the nature of the possible effect of an accident and an opportunity to contribute effectively, as appropriate, to decisions concerning hazardous installations and the development of community emergency preparedness plans

Communication Systems

**Worker notification and communication:** Alarm bells, visual alarms or other forms of communication should be used to reliably alert workers to an emergency. Related measures include:

- Testing warning systems at least annually (fire alarms monthly), and more frequently if required by local regulations, equipment or other considerations
- Installing a back-up system for communications on-site with off-site resources, such as fire departments, in the event that normal communication methods may be inoperable during an emergency

**Community Notification:** If a local community may be at risk from a potential emergency arising at the facility, the company should implement communication measures to alert the community, such as:

- Audible alarms, such as fire bells or sirens
- Fan out telephone call lists
- Vehicle mounted speakers
- Communicating details of the nature of the emergency
- Communicating protection options (evacuation, quarantine)
- Providing advice on selecting an appropriate protection option
3.4 WASTE MANAGEMENT

Mines generate large volumes of waste. Structures such as waste dumps, tailing impoundments/dams and containment facilities should be planned, designed and operated such that geotechnical risks and environmental impacts are appropriately assessed and managed throughout the entire mine cycle.

Waste Rock Dumps

Recommendations for management of waste rock dumps include the following:

- Dumps should be planned with appropriate terrace and lift height specifications based on the nature of the material and local geotechnical considerations to minimize erosion and reduce safety risks
- Management of Potentially Acid Generating (PAG) wastes should be undertaken as described in the guidance below

Waste Geochemical Characterization

Mining operations should prepare and implement ore and waste geochemical characterization methods for proper routing of Potentially-Acid-Generating (PAG) materials and ARD management programs that include the following elements:

- Conducting a comprehensive series of accelerated leaching tests from feasibility study stage onwards, to evaluate the potential for ARD in all formations foreseen to be disturbed or otherwise exposed by the mine according to internationally recognized methodologies


- Conducting comprehensive ARD / metals leaching (ML) testing / mapping on an ongoing basis with decreasing block size as formations are transferred from long- to medium- and short-term mining plans;
- Implementation of ARD and ML preventive actions to minimize ARD including:
  - Limiting exposure of PAG materials by phasing of development and construction, together with covering, and/or segregating runoff for treatment
  - Implementation of water management techniques such as diverting clean runoff away from PAG materials, and segregating “dirty” runoff from PAG materials for subsequent treatment; grading PAG material piles to avoid ponding and infiltration; and removing pit water promptly to minimize acid generation
• Controlled placement of PAG materials (including wastes) to provide permanent conditions that avoid contact with oxygen or water including:
  ◦ Submerging and/or flooding of PAG materials by placing PAG materials in an anoxic (oxygen free) environment, typically below a water cover
• Isolating PAG materials above the water table with an impermeable cover to limit infiltration and exposure to air. Covers are typically less of a concern in arid climates where there is limited precipitation, and should be appropriate for local climate and vegetation (if any)
  ◦ Blending of PAG materials with non-PAG or alkaline materials can also be employed to neutralize acid generation, as appropriate.
  Blending should be based on full characterization of each of the blended materials, the ratio of alkaline materials to acid generating materials, the case histories of failed operations and the need for static and long-term kinetic tests

Non-hazardous solid waste should be collected for recycling or disposal at an approved sanitary landfill. External landfills should be audited by the mine to ensure appropriate waste management practices. Non-hazardous solid waste should not be disposed of together with waste rock or overburden except under exceptional circumstances to be fully documented in the environmental and social assessment of the project.

Tailings

Strategies should consider the site topography, downstream receptors and the physical nature of tailings (e.g. projected volume, grain size distribution, density, water content, among other issues).


Riverine (e.g. rivers, lakes and lagoons) or shallow marine tailings disposal is not considered good international industry practice. By extension, riverine dredging which requires riverine tailings disposal is also not considered good international practice.

Waste Storage

Hazardous waste should be stored so as to prevent or control accidental releases to air, soil and water resources in area location where:

• Store in closed containers away from direct sunlight, wind and rain
• Secondary containment systems should be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment
• Secondary containment is included wherever liquid wastes are stored in volumes greater than 220 liters. The available volume of secondary containment should be at least 110 percent of the largest storage container, or 25 percent of the total storage capacity (whichever is greater), in that specific location
Monitoring

Monitoring activities associated with the management of hazardous and non-hazardous waste should include:

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labeled and stored. When significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:
  - Inspection of vessels for leaks, drips or other indications of loss
  - Identification of cracks, corrosion or damage to tanks, protective equipment or floors
  - Verification of locks, emergency valves and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied)
  - Checking the operability of emergency systems
  - Documenting results of testing for integrity, emissions or monitoring stations (air, soil vapor or groundwater)
  - Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage

- Regular audits of waste segregation and collection practices
- Tracking of waste generation trends by type and amount of waste generated, preferably by facility departments

- Characterizing waste at the beginning of generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste, especially hazardous wastes
- Keeping manifests or other records that document the amount of waste generated and its destination
- Periodic auditing of third party treatment, and disposal services including re-use and recycling facilities when significant quantities of hazardous wastes are managed by third parties. Whenever possible, audits should include site visits to the treatment storage and disposal location
- Regular monitoring of groundwater quality in cases of Hazardous Waste on site storage and/or pretreatment and disposal
- Monitoring records for hazardous waste collected, stored or shipped should include:
  - Name and identification number of the material(s) composing the hazardous waste
  - Physical state (i.e., solid, liquid, gaseous or a combination of one or more of these)
  - Quantity (e.g., kilograms or liters, number of containers)
  - Method and date of storing, repacking, treating or disposing at the facility, cross-referenced to specific manifest document numbers applicable to the hazardous waste
  - Location of each hazardous waste within the facility, and the quantity at each location
3.5 NOISE AND VIBRATION

Sources of noise emissions associated with mining may include noise from vehicle engines, loading and unloading of rock into steel dumpers, chutes, power generation and other sources related to construction and mining activities. Additional examples of noise sources include shoveling, ripping, drilling, blasting, transport (including corridors for rail, road and conveyor belts), crushing, grinding and stockpiling. Good practice in the prevention and control of noise sources should be established based on the prevailing land use and the proximity of noise receptors such as communities or community use areas.

Recommended management strategies include:

- Where necessary, noise emissions should be minimized and controlled through the application of techniques which may include:
  - Implementation of enclosure and cladding of processing plants
  - Installation of proper sound barriers and/or noise containments, with enclosures and curtains at or near the source equipment (e.g. crushers, grinders and screens)
  - Installation of natural barriers at facility boundaries, such as vegetation curtains or soil berms
  - Optimization of internal-traffic routing, particularly to minimize vehicle reversing needs (reducing noise from reversing alarm) and to maximize distances to the closest sensitive receptors

Mines should minimize significant sources of vibration, such as through adequate design of crusher foundations. For blasting-related emissions (e.g. vibration, air blast, overpressure or fly rock), the following management practices are recommended:

- Mechanical ripping should be used, where possible, to avoid or minimize the use of explosives
- Use of specific blasting plans, correct charging procedures and blasting ratios, delayed/microdelayed or electronic detonators and specific in-situ blasting tests (the use of downhole initiation with short-delay detonators improves fragmentation and reduces ground vibrations)
- Development of blast design, including a blasting-surfaces survey, to avoid over confined charges, and a drill-hole survey to check for deviation and consequent blasting recalculations
- Implementation of ground vibration and overpressure control with appropriate drilling grids
- Adequately designing the foundations of primary crushers and other significant sources of vibrations

Some recommended noise reduction and control strategies to consider in areas close to community areas include:

- Planning activities in consultation with local communities so that activities with the greatest potential to generate noise are planned during periods of the day that will result in least disturbance
- Avoiding or minimizing project transportation through community areas
Monitoring

Noise monitoring programs should be designed and conducted by trained specialists. Typical monitoring periods should be sufficient for statistical analysis and may last 48 hours with the use of noise monitors that should be capable of logging data continuously over this time period, or hourly, or more frequently, as appropriate (or else cover differing time periods within several days, including weekday and weekend workdays). The type of acoustic indices recorded depends on the type of noise being monitored, as established by a noise expert. Monitors should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface (e.g., wall). In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the facility or noise source(s) under investigation.

### NOISE LEVEL GUIDELINES

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Daytime 07:00 - 22:00</th>
<th>Nighttime 22:00 - 07:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential; institutional; educational&lt;sup&gt;2&lt;/sup&gt;</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Industrial; commercial</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

1 Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.
2 For acceptable indoor noise levels for residential, institutional, and educational settings refer to WHO (1999).

Noise Level Guidelines

Noise impacts should not exceed the levels listed below, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

Additional noise reduction options that should be considered include:

- Selecting equipment with lower sound power levels
- Installing silencers for fans
- Installing suitable mufflers on engine exhausts and compressor components
- Installing acoustic enclosures for equipment casing radiating noise
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m² in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective
- Installing vibration isolation for mechanical
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas
- Taking advantage of the natural topography as a noise buffer during facility design
- Developing a mechanism to record and respond to complaints
4. contaminated land

When contamination of land is suspected or confirmed during any project phase, the cause of the uncontrolled release should be identified and corrected to avoid further releases and associated adverse impacts.

**RISK SCREENING**

This step is also known as “problem formulation” for environmental risk assessment. Where there is potential evidence of contamination at a site, the following steps are recommended:

- Identification of the location of suspected highest level of contamination through a combination of visual and historical operational information
- Sampling and testing of the contaminated media (soils or water) according to established technical methods applicable to suspected type of contaminant: Massachusetts Department of Environment. [http://www.mass.gov/dep/cleanup](http://www.mass.gov/dep/cleanup)
- Evaluation of the analytical results against the local and national contaminated sites regulations. In the absence of such regulations or environmental standards, other sources of risk-based standards or guidelines should be consulted to obtain comprehensive criteria for screening soil concentrations of pollutants
- Verification of the potential human and/or ecological receptors and exposure pathways relevant to the site in question

**To determine whether risk management actions are warranted, the following assessment approach should be applied** to establish whether the three risk factors of ‘Contaminants’, ‘Receptors’ and ‘Exposure Pathways’ co-exist, or are likely to co-exist, at the project site under current or possible future land use:

- **Contaminant(s):** Presence of hazardous materials, waste or oil in any environmental media at potentially hazardous concentrations
- **Receptor(s):** Actual or likely contact of humans, wildlife, plants and other living organisms with the contaminants of concern
- **Exposure pathway(s):** A combination of the route of migration of the contaminant from its point of release (e.g., leaching into potable groundwater) and exposure routes
INTERIM RISK MANAGEMENT

Interim risk management actions should be implemented at any phase of the project life cycle if the presence of land contamination poses an “imminent hazard”, i.e., representing an immediate risk to human health and the environment if contamination were allowed to continue, even a short period of time. **Examples of situations considered to involve imminent hazards include, but are not restricted to:**

- Presence of an explosive atmosphere caused by contaminated land
- Accessible and excessive contamination for which short-term exposure and potency of contaminants could result in acute toxicity, irreversible long term effects, sensitization or accumulation of persistent biocumulative and toxic substances
- Concentrations of pollutants at concentrations above the Risk Based Concentrations (RBCs) or drinking water standards in potable water at the point of abstraction. For example, USEPA Region 3 Risk-Based Concentrations (RBCs) [http://www.epa.gov/reg3hwmd/risk/human/index.htm](http://www.epa.gov/reg3hwmd/risk/human/index.htm)

Appropriate risk reduction should be implemented as soon as practicable to remove the condition posing the imminent hazard. An assessment of contaminant risks needs to be considered in the context of current and future land use and development scenarios (e.g., residential, commercial, industrial and urban parkland or wilderness use).

Example risk mitigation strategies for contaminant source and exposure concentrations include:

- Soil, sediment and sludge:
  - In situ biological treatment (aerobic or anaerobic)
  - In situ physical/chemical treatment (e.g., soil vapor extraction with off-gas treatment, chemical oxidation)
  - In situ thermal treatment (e.g., steam injection, 6-phase heating)
  - Ex situ biological treatment (e.g., excavation and composting)
  - Ex situ physical/chemical treatment (e.g., excavation and stabilization)
  - Ex situ thermal treatment (e.g., excavation and thermal desorption or incineration)
  - Containment (e.g. landfill)
  - Natural attenuation
  - Other treatment processes

- Groundwater, surface water and leachate:
  - In situ biological treatment (aerobic and/or aerobic)
  - In situ physical/chemical treatment (e.g., air sparging, zero-valent iron permeable reactive barrier)
  - Ex situ biological, physical and or chemical treatment (i.e., groundwater extraction and treatment)
  - Containment (e.g., slurry wall or sheet pile barrier)
  - Natural attenuation
  - Other treatment processes
Example risk mitigation strategies for exposure pathways include:

- Providing an alternative water supply to replace, for example, a contaminated groundwater supply well
- Capping contaminated soil with at least 1m of clean soil to prevent human contact, as well as plant root or small mammal penetration into contaminated soils
- Paving over contaminated soil as an interim measure to negate the pathway of direct contact or dust generation and inhalation
- Using an interception trench and pump and treat technologies to prevent contaminated groundwater from discharging into fish streams

The above-referenced containment measures should also be considered for immediate implementation in situations where source reduction measures are expected to take time.

Example risk mitigation strategies for receptors include:

- Limiting or preventing access to contaminant by receptors (actions targeted at the receptor may include signage with instructions, fencing or site security)
- Imposing health advisory or prohibiting certain practices leading to exposure such as fishing, crab trapping, shellfish collection
- Educating receptors (people) to modify behavior in order to reduce exposure (e.g., improved work practices and use of protective clothing and equipment)
5. structural safety of project infrastructure

The following issues should be considered and incorporated as appropriate into the planning, siting and design phases of a project:

• Inclusion of buffer strips or other methods of physical separation around project sites to protect the public from major hazards associated with hazardous materials incidents or process failure, as well as nuisance issues related to noise, odors or other emissions

• Incorporation of siting and safety engineering criteria to prevent failures due to natural risks posed by earthquakes, tsunamis, wind, flooding, landslides and fire. To this end, all project structures should be designed in accordance with engineering and design criteria mandated by site-specific risks, including but not limited to seismic activity, slope stability, wind loading and other dynamic loads

• Application of locally regulated or internationally recognized building codes to ensure structures are designed and constructed in accordance with sound architectural and engineering practice, including aspects of fire prevention and response


• Engineers and architects responsible for designing and constructing facilities, building, plants and other structures should certify the applicability and appropriateness of the structural criteria employed

International codes, such as those compiled by the International Code Council (ICC), are intended to regulate the design, construction and maintenance of a built environment and contain detailed guidance on all aspects of building safety, encompassing methodology, best practices and documenting compliance.
6. construction and decommissioning

SOIL EROSION

Soil erosion may be caused by exposure of soil surfaces to rain and wind during site clearing, earth moving and excavation activities. The mobilization and transport of soil particles may, in turn, result in sedimentation of surface drainage networks, which may result in impacts to the quality of natural water systems and ultimately the biological systems that use these waters.

Recommended soil erosion and water system management approaches include:

Sediment mobilization and transport

- Reducing or preventing erosion by:
  - Scheduling to avoid heavy rainfall periods (i.e., during the dry season) to the extent practical
  - Contouring and minimizing length and steepness of slopes
  - Mulching to stabilize exposed areas
  - Re-vegetating areas promptly
  - Designing channels and ditches for post-construction flows
  - Lining steep channel and slopes (e.g., use jute matting)
- Reducing or preventing off-site sediment transport through use of settlement ponds, silt fences and water treatment, and modifying or suspending activities during extreme rainfall and high winds to the extent practical

Road design

- Limiting access road gradients to reduce runoff-induced erosion
- Providing adequate road drainage based on road width, surface material, compaction and maintenance

Disturbance to water bodies

- Depending on the potential for adverse impacts, installing free-spanning structures (e.g., single span bridges) for road watercourse crossings
- Restricting the duration and timing of in-stream activities to lower low periods and avoiding periods critical to biological cycles of valued flora and fauna (e.g., migration, spawning, etc.)
- For in-stream works, using isolation techniques such as berming or diversion during construction to limit the exposure of disturbed sediments to moving water
- Consider using trenchless technology for pipeline crossings (e.g., suspended crossings) or installation by directional drilling
Structural (slope) stability

- Providing effective short term measures for slope stabilization, sediment control and subsidence control until long term measures for the operational phase can be implemented
- Providing adequate drainage systems to minimize and control infiltration

MINE CLOSURE AND POST-CLOSURE

A mine closure plan that incorporates both physical rehabilitation and socio-economic considerations should be an integral part of the project life cycle and should be designed so that:

- Future public health and safety are not compromised
- The after-use of the site is beneficial and sustainable to the affected communities in the long term
- Adverse socio-economic impacts are minimized and socio-economic benefits are maximized

The closure plan should be regularly updated and refined to reflect changes in mine development and operational planning, as well as the environmental and social conditions and circumstances.

Financial Feasibility

The costs associated with mine closure and post-closure activities, including post-closure care, should be included in business feasibility analyses during the planning and design stages. Minimum considerations should include the availability of all necessary funds, by appropriate financial instruments, to cover the cost of closure at any stage in the mine life, including provision for early or temporary closure. Funding should be by either a cash accrual system or a financial guarantee. The two acceptable cash accrual systems are fully funded escrow accounts (including government managed arrangements) or sinking funds. An acceptable form of financial guarantee must be provided by a reputable financial institution.
7. additional guidelines and monitoring

<table>
<thead>
<tr>
<th>EFFLUENT GUIDELINES*</th>
<th>Pollutants</th>
<th>Units</th>
<th>Guideline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids</td>
<td>mg/L</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>S.U.</td>
<td>6-9</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>BOD₅</td>
<td>mg/L</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Chromium (VI)</td>
<td>mg/L</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Cyanide</td>
<td>mg/L</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cyanide Free</td>
<td>mg/L</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Cyanide WAD</td>
<td>mg/L</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Iron (total)</td>
<td>mg/L</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/L</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Phenols</td>
<td>mg/L</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>&lt;3 degree differential</td>
<td></td>
</tr>
</tbody>
</table>

*These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific, local project conditions should be justified in the environmental assessment.

**ENVIRONMENTAL MONITORING**

Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents and resource use applicable to the particular project. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.
**OCCUPATIONAL HEALTH AND SAFETY**

Beyond the scope of this project - refer to the EHS General and Mining-specific Guidelines for full guidance.

### SUMMARY OF RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT ACCORDING TO HAZARD

<table>
<thead>
<tr>
<th>Objective</th>
<th>Workplace Hazards</th>
<th>Suggested PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye and face protection</strong></td>
<td>Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.</td>
<td>Safety Glasses with side-shields, protective shades, etc.</td>
</tr>
<tr>
<td><strong>Head protection</strong></td>
<td>Falling objects, inadequate height clearance, and overhead power cords.</td>
<td>Plastic Helmets with top and side impact protection.</td>
</tr>
<tr>
<td><strong>Hearing protection</strong></td>
<td>Noise, ultra-sound.</td>
<td>Hearing protectors (ear plugs or ear muffs).</td>
</tr>
<tr>
<td><strong>Foot protection</strong></td>
<td>Falling or rolling objects, pointed objects. Corrosive or hot liquids.</td>
<td>Safety shoes and boots for protection against moving &amp; falling objects, liquids and chemicals.</td>
</tr>
<tr>
<td><strong>Hand protection</strong></td>
<td>Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.</td>
<td>Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.</td>
</tr>
<tr>
<td><strong>Respiratory protection</strong></td>
<td>Dust, fogs, fumes, mists, gases, smokes, vapors.</td>
<td>Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapors and gases). Single or multi-gas personal monitors, if available.</td>
</tr>
<tr>
<td></td>
<td>Oxygen deficiency.</td>
<td>Portable or supplied air (fixed lines). On-site rescue equipment.</td>
</tr>
<tr>
<td><strong>Body/leg protection</strong></td>
<td>Extreme temperatures, hazardous materials, biological agents, cutting and laceration.</td>
<td>Insulating clothing, body suits, aprons etc. of appropriate materials.</td>
</tr>
</tbody>
</table>
about NBS

A Canadian non-profit established in 2005, the Network for Business Sustainability produces authoritative resources on important sustainability issues – with the goal of changing management practice. We unite thousands of researchers and professionals worldwide who believe passionately in research-based practice and practice-based research.

NBS is funded by the Social Sciences and Humanities Research Council of Canada, the Richard Ivey School of Business (at The University of Western Ontario), the Université du Québec à Montréal and our Leadership Council.

about SFU Beedie

Since the creation of Canada’s first Executive MBA in 1968, the Beedie School of Business has championed lifelong learning, productive change and the need to be innovative as it delivers research and teaching that make an impact. In particular, it has been recognized for its contributions to knowledge creation in the areas of globalization and emerging markets; innovation and technology; sustainability and governance; and capital and risk management. The school’s goal is to produce broadly educated, enterprising and socially responsible managers capable of making lasting contributions to their communities.

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Asanko Gold

Mitacs Accelerate Program

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The Social Sciences and Humanities Research Council of Canada

Start Here: World Bank EHS Guidelines (for Small Producing Mining Companies)